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1 23. Woody Debris Replenishment – [Moderate]

1.1 Introduction

Wood habitat restoration discussed in the Stream Habitat Restoration Guidelines (SHRG) is organized under four techniques: 1) Debris Jams, 2) Large Wood Replenishment 3) Log Cover, and 4) Structures to Create and Maintain a Diverse Channel Bedform. In nature, habitat functions aren't organized into four categories. Wood habitat functions change depending on a wide variety of geomorphic, biologic, hydrologic, hydraulic and watershed processes that occur over time. Wood habitat can be variable between and within watersheds. Local watershed knowledge and watershed analysis may be helpful used during the design of wood related habitat to maximize success. Monitoring of a sub sample of restoration sites is an important aspect of restoration efforts to validate the restoration effort

Large wood techniques described in the SHRG overlap. For example, a debris jam can also provide log cover, and log cover may create scour resulting in pool and spawning habitat. The techniques provided facilitate understanding natural large wood processes. The goal is to emulate and "jump-start" natural processes that benefit aquatic environments through design and construction. The objective is to reach a properly functioning condition calling for little or no project maintenance or repair.

1.1.1 Description of Technique

This technique places Slash, Logs and Trees on banks and gravel bars and in the stream or river channel for easy recruitment, or key pieces placed in the channel to catch and collect floating debris. The goal is to address the limiting factors of a deficiency of large wood within a stream channel and to begin to re-establish natural accumulations and complex habitat associated with large wood. This may require the delivery of large pieces that may form debris jams or only small material in areas where old key pieces still exist and only require mobile wood to rack against the large key piece to enhance habitat. It includes taking debris from reservoirs and upstream of bridges and placing it downstream to restore the natural rate of recruitment of debris. A more expensive way to deliver whole trees to stream systems is by a helicopter. Several projects have occurred in the northwest that have used helicopters to deliver small logs up to whole old growth sized trees. Other methods include stream corridor forest stand "thinning," outside of a functional stream "buffer zone." Cut timber is used for LWD placement at low impact access points (Palix River, WRIA 24.0435, 1998). Redistribution of downed wood catastrophically produced by land use mass wasting has been successful in stabilizing hill slopes and restoring bedload transfer balance and channel form to impacted stream reaches (Spyder Creek, WRIA 24.0704, 1999)

In addition to augmenting dead wood within the stream system, living riparian communities can also be augmented through addition of living wood material. End dumping cottonwood, willow and red osier dogwood cuttings from bridges has been successful in east side environments. As the material moves downstream, it is transported against banks and on top of gravel bars where it sprouts and grows.

The method uses a managed input approach to habitat restoration. It's objective is to compensate for a lack of supply of woody material, both live and dead. Live woody material that has the ability to sprout can be used to revegetate banks and gravel bars where is it deposited. Dead woody material can rack up against downstream key piece members of large wood that area immobile creating complex aquatic habitat. This method relies on flow events (which are unpredictable) to distribute the material throughout the downstream reach. For this reason, it does not produce immediate results and desired results make take years to develop, if they do at all. This method is best applied in conjunction with riparian zone restoration to provide a long-term source of woody material to the stream (see Riparian Restoration technique).

1.1.2 Physical and Biological Effects

Wood replenishment projects provide a source of wood to interact with the streams and rivers in the most natural way possible. In some environments this technique may not be appropriate due to infrastructure around human settlement, the risk for flooding, bank erosion or damage to private property. It has the low risk in a wild land environment and a higher risk of conflicts in populated areas. A cumulative effects analysis should be undertaken to insure the source of wood used for this technique doesn't impact or reduce habitat for other fish and wildlife species that may rely on the wood wherever it is acquired.

In valley bottoms and watersheds that have been heavily logged or grazed causing a loss in riparian function, wood replenishment can accelerate recovery processes. Disturbed or cleared riparian areas can take decades or centuries to grow wood large enough to influence the channel structure. Only then will the channel respond by laterally scouring around and under large wood to create pool habitat, reduce broadcast scour, sort and retain gravel for spawning and provide complex cover and rearing habitat. Supplementing the channel with large wood reduces the time of recovery by importing wood material that may take 100 years to grow on site. Large wood is essential for lasting function. The introduction of small wood without the large wood component will have relatively short-term benefits.

Splash- dams were once commonly used in southwest Washington Rivers to transport logs downstream to mills. This practice impacted ecosystems and watershed geomorphology so severely it may be impossible to determine where the river once was, and how the river functioned to provide habitat that evidently was tremendously productive by today's standards. Channels were eroded to the bedrock or at least incised; bedrock was blasted and reconfigured to aid in lumber transport. Channels have also been degraded by riparian area harvest, increases in peak flow hydrology due to watershed timber harvesting and road building and natural and human caused fire disturbance. In some cases these conditions are permanent because the process that formed previous channel conditions were geologic in nature such as catastrophic debris torrents or landslides. The only way to replicate these processes would be with an equivalent expenditure of energy in the form of heavy equipment, large volumes of large wood and re-grading of valley bottom sediment or another geologic scale event.

In many cases degraded stream channels can be recovered over time as large old growth sized trees re-grow and begin to fall in to the channel. This is a more likely occurrence in smaller channels than large. Regardless of the size it will take centuries to occur naturally because of the size of tree needed to influence and recovery many stream channels. One of the goals of large wood introductions is to accelerate this process by importing large wood and bridge the gap between riparian stand development and the beginning of large wood channel recovery. By accelerating the recovery process the goal is to increase biologic response and basin carrying capacities as riparian vegetation communities mature.

Stream channels that have wood replenishment increase the amount of gravel sorting and retention behind or above the imported wood material. The rate, extent, and yearly timing of bed scour and fine sediment flushing is commonly dependent upon volume of LWD and the mechanical strength, or decay rate, of the LWD forming bed controls. Rivers, which have mostly relatively fast-decaying alder LWD, or lack key size piece LWD, have higher rates of bed disturbance than rivers, which have fir/cedar key size LWD. Catastrophic gravel bed broadcast scour typically occur in the winter when fish eggs from many species are in the gravel. Alder LWD has a much shorter life span than conifer LWD of the same size. Large LWD creates scour pools as the water flows around over or under the wood and can protect gravel-spawning beds from broadcast scour of entire beds. This provides resilient complex cover habitat that can be utilized by salmonids. Nutrient retention increases when wood is delivered to a stream channel. Root wads, branches and overhanging wood material tends to trap other wood material, leaves, anadromous fish carcasses and other organic matter. This material provides an excellent food base for macroinvertebrate populations throughout the riparian area. Fine woody debris captured by LWD creates prime nursery habitat at times of the year when the most vulnerable salmonid life stages may exist.

Down logs in the channel and in the floodplain serve a variety of functions for wildlife species. Smaller logs provide escape cover and shelter for small mammals, amphibians and reptiles (Bull et al 1997). Increased log volume may increase densities of certain amphibians and small mammals (Butts and McComb 2000). Small mammals use logs for runways, which in turn attracts predators of these small mammals (Bull and Henjum 1990). Larger diameter logs, especially hollow logs, provide denning, resting, and litter rearing sites for larger vertebrates such as marten, bobcat and black bears (Bull et al 1997). High densities of large logs and upturned stumps provide security cover for lynx kittens (Koehler and Aubry 1994). Jackstrawed logs provide not only excellent cover for small mammals, but prime foraging habitat for mink, marten and cougar (Bull et al 1997).

Free flowing rivers provide critical woody debris supply to floodplains, estuaries and ocean environments. Restoration of properly functioning riverine conditions allows the natural process of transport and distribution of LWD. If this natural process is disrupted, in the loss of LWD through decay, and lack of LWD recruitment from upstream sources that deplete wood supply, fish and wildlife populations will be impacted. Floodplain wood debris provides habitat for amphibians, birds, macroinvertabrates and fish habitat during flood flows. Wood that deposits on open gravel bars encourages fine sediment deposition and sites for riparian vegetation development. Wood accumulations on ocean beaches provide ecologic habitat value to wildlife and aquatic species in shoreline environments.

1.1.3 Application of Technique

A basic understanding of the watershed processes and geomorphic history creating the loss of habitat should be completed. Determining the cause of the problems and addressing those factors if they still exist, may best be given priority to any wood supplementation work. This technique is best performed in partnership with local stakeholders, fish and wildlife agencies and tribes.

This technique is applicable in areas where the source of woody material has been removed or reduced such as below reservoirs, as mitigation for lost wood recruitment due to historic riparian harvest and livestock grazing, and as mitigation for historical stream cleanout and in areas where. It works best to apply this technique in areas where natural wood recruitment will eventually recover. Placing the material in an upstream transport reach is one way to allow the wood to be naturally deposited. During floods, LWD moves to downstream to depositional reaches and orients Subsequent high flows will scour and sort gravel leading to excellent fish habitat. To maximize the benefits, it is important to match the size of wood with the streams ability to transport and move it to a location where habitat can be developed. Large trees with root wads work best in larger streams and rivers.

When some channel roughness and riparian vegetation exists downstream, it can be improved and enhanced using cuttings to develop new riparian tree growth. In eastern Washington and some western Washington floodplains, use cottonwood, willow and dogwood. By far the best success rates have been achieved using willow cuttings. Willows are generally twice as successful as dogwood or cottonwood. Cottonwood is more successful when larger live pieces or live logs are used. It takes up to a year for the cottonwood to sprout. Large pieces provide more energy stores to sustain the new tree as it grows. Red osier dogwood is established by planting cuttings. Dogwoods sprout best when cuttings are scarified and growth hormones are applied.

In areas with no riparian area roughness and steeper eroding banks, this technique should not be used since there would be limited areas where the cuttings could deposit and establish. In severely disturbed riparian areas active bank pull back and/or plantings should occur.

1.2 Scale

Wood habitat, function, transport and deposition changes depending on the size of the stream, river and wood. As one moves from the headwaters of any watershed down to the ocean, the function and behavior of wood changes, as the hydrology and fluvial geomorphology acting on the wood changes.

In small streams, trees can be large enough to remain immobile when they fall into the channel. The hydraulic forces acting around the large wood create pools and redistribute or accumulate gravel around the immobile wood debris. In larger streams and small rivers, very large relatively immobile trees float during peak flows, and captures, smaller pieces that are floating downstream. Over time the complexity and size of a woody material structures originating from a single tree can grow to a lateral or channel-spanning logjam that backwaters entire stream reaches.

In larger rivers, peak flows will break up most or all channel-spanning logjams. Wood is typically transported longer distances, but it can accumulate in lateral logjams, and on point bars. Large whole trees with root wads are the primary source of key-piece wood. All debris jams have on or two immobile key pieces of large wood that prevents accumulated wood racked upstream of the logjam from moving downstream. These pieces of wood are referred to as key piece wood. Without them a debris jam wouldn't exist. In these environments the larger wood that is transported in more confined reaches begins to deposit in unconfined reaches. Larger trees that deposit accumulate and strain smaller sized wood that would tend to be transported. The size of the tree and location within the watershed are factors controlling where and to what extent wood deposits and habitat is formed.

How much is enough? Martin Fox of Center for Streamside Studies has recently surveyed 150 stream segments draining unmanaged watersheds. Based on the assumption that streams draining unmanaged forest incorporate the range of conditions that salmonids in those basins have adapted to. Since watersheds are so variable it is recommended that a watershed assessment be used to understand historical processes and current opportunities regarding large wood additions (Roni et al. 2002).

1.3 Risk and Uncertainty

This technique doesn't work well in urban environments, unless agreements are made upfront that long-term maintenance of the project may include wood clearing around culverts and or bridges. The risk of downstream transport of wood to culverts and bridges is highest if small transportable wood is utilized. It decreases as the size of wood increases. Wood supplementation emulates natural wood habitat behavior that could easily result in unintended flooding, or wood deposits behind bridges and culverts resulting in road washouts or bridge abutment scour. Urban stream channels with substantial lengths of greenway and floodplain space and adequate storm water management would be better suited for large wood supplementation.

Due to the nature of this technique it is best suited for use in a forested environment with a substantial amount of downstream area wood can be deposited in. Downstream culverts and bridges should be identified before design and implementation proceed to insure road crossing damage doesn't occur as a result of this technique. A good understanding of the watershed is essential to correctly sizing supplemental wood used in this technique. There is no reason to add small mobile wood if the large wood needed to collect it does not exist downstream. In these cases key large pieces should be placed downstream to re-establish the ability to capture smaller sized wood during floods. Key piece placements are discussed in more detail within the Debris Jam technique. A watershed assessment would help determine whether this technique is appropriate for a particular watershed and to what degree it should be applied. Streams that are largely transporting small wood material during floods with few areas of potential deposition should not use this technique.

1.4 Data Collection and Assessment

Understanding the natural plant communities and expected large wood volumes, size and function are important in order to obtain the correct size and type of large wood to use in the supplementation work. Peak flow hydrology and the ability of a stream channel to transport large wood is an essential part of the process for determining the size and volume of large wood used in any stream project (Castro and Sampson 2001).

In all cases it is useful to identify and study project "reference reaches." A good reference reach is commonly found upstream of the project reach and may be a reach in another stream with similar hydro geomorphic attributes, but possessing the desired habitat elements. Reference reaches help show what potential LWD loading levels may do and can be "calibrated" over time as monitoring results on the project and reference sites become available.

Wood supplementation with the goal of increasing cottonwood, dogwood or willow propagation does not need the level analysis as projects using large wood for in stream habitat.

Riparian Area Tree Size Potential – Geomorphically based Riparian Plant Community Classification, i.e., Bud Kovalchik (USFS, 2001), Rex Crawford (WA DNR, 2001).

1.5 Methods and Design

1.5.1 Size and Volume Considerations

Large wood supplementation should have specific objectives that relate to the mobility of the wood being placed in the stream channel. If the objective is to have stable wood needed to collect smaller wood to form complex habitat, then large wood additions would use progressively larger and longer material as one moves from the headwaters downstream.

The Pacific Northwest has very few undisturbed areas to determine what is "natural" for any given stream channel. Most of our low elevation stream systems have been degraded many decades ago. The few places that have not been disturbed are in Alaska, National Parks or high elevation wilderness areas. What can be determined from these areas must then be applied with caution to areas with no reference sites. Montgomery et al. (1995) found that wood loading in Alaska managed and managed streams was related to pool development. In unmanaged streams LWD frequency was 0.4 pieces per square meter of channel length. However in 73% of the managed streams the large wood loading was less than 0.2 pieces per meter of channel length. Pool formation within the forested channels studied was highly dependent on scour around LWD and that the pool frequency in areas with high wood loading was 2-4 channel widths. This is less than the 5-7 channel widths indicated by Leopold et al., 1964 for unobstructed alluvial channels. Channel width played an important role in wood function in Alaska. As width increases the ability of the large wood to force scour pool decreases. In other words it takes larger sized wood to force scour pools as one enters larger stream systems and points to the importance of matching the wood size with the stream size one is working in to maximize benefits.

This technique can be implemented on a variety of scales depending on the objectives. In some watersheds the utilization of willow, cottonwood and dogwood cuttings can jumpstart riparian colonization and bank stabilization. This is more useful when downstream riparian areas aren't severely degraded and still have some roughness elements that could collect floating live cuttings. Using live cuttings isn't recommended in areas with no riparian area roughness or vegetation that can collect cuttings. In these areas the riparian area should be actively planted.

In west side environments slash and smaller wood additions could be used to supply a fine wood component and complexity to existing large trees or constructed wood habitat. On a larger scale whole trees can be flown in and placed to allow more intensive habitat development in previously degraded valley bottoms.

Location of wood placements in degraded environments that simulate key piece members required for debris jams depend heavily on a geomorphic and hydraulic analysis of the project area. Wood supplementation with large material that is immobile overlaps into the Debris Jam technique. See Debris Jam techniques for details on process, function, data collection and designs

1.5.2 Floodplain Loading

Wood replenishment in alluvial channels requires more thought than in steeper incised channels. Alluvial channels can rapidly migrate if large wood is concentrated in areas that have very little floodplain or bank roughness. In disturbed alluvial environments the risk for channel avulsions and instability is very high if wood is only placed in the channel, or if LWD is artificially fixed in place regardless of natural floodplain or bank roughness. It is important to achieve a balanced LWD loading volume and density in the channel, and across all floodplain areas, if wood loading is completed on a large scale and floodplain roughness is low due to previous harvest or land clearing.

Floodplain wood loading emulates natural process. In healthy channels if a log jam forms and creates lateral instability on the opposite bank with large trees on it, the tree will be undercut and fall over. The tree and root wad naturally armor the bank forcing the channel to increase in capacity by vertically scouring a pool around the wood. Flood plain, gravel bar and bank wood loading provide a source of roughness that is as important as any wood placed in the channel.

Wood loading in disturbed alluvial environments should examine inundation across all of the project reach flood surfaces to determine avulsion risk and lateral bank stability. Lateral bank erosion in incised stream channels provides new flood prone areas that ultimately benefits aquatic habitat. However, excessive in-channel wood loading without sufficient floodplain and bank wood loading can create rapid bank erosion that overwhelms downstream sediment transport capacity creating unintended instability. If too much bedload is released into the stream at once the load may move as a slow debris wave downstream, resulting in serial channel braiding, and dam-break debris flows as the wave transports downstream.

One way to check inundation and potential response to wood loading is to collect cross section information, determine peak flow hydrology for channel forming and greater discharges and determine stage discharge relationships with a hydraulic model. Channel capacity and bank shear stress can be compared with different wood loading scenarios to gain some understanding of channel stability and risk.

Hydrologists, Fish Biologists, Geomorphologists and Hydraulic Engineers with experience in design, construction and monitoring large wood material may be used especially when working in areas where large sized wood can be transported off-site.

1.5.3 Permitting

Information regarding specific permits necessary to proceed with construction is addressed in Chapter 4.6. Information that will generally be required to obtain permits for in-stream wood placement include the volume of the wood and rock ballast incorporated in the project, wetland locations, design drawings, site maps, access areas, sediment control plan, and re-vegetation plan for disturbed sites. Biological considerations here also as they relate to aquatic resources and the endangered species act should be considered.

1.5.4 Construction

By nature this type of project is very low impact since the delivery of wood often occurs close to a road, bridge, by helicopter, or as part of a comprehensive land use management plan. As with all in stream projects heavy equipment used should be cleaned and have all ground disturbance replanted and repaired following the work. Wood species type, size and volume and decay condition should be clearly specified for any construction contract that fits the design specifications. Refer to the Construction Appendix for further discussion of the use of heavy equipment, impacts, and contracting considerations.

1.5.5 Cost Estimation

Costs for wood supplementation are highly variable. Wood costs can range from free wood to $1000 per tree delivered to the site. The cost to place a wood varies greatly depending on the distance from an access road or harvest site and the type of equipment needed to place the wood. Large excavators used to place the wood can cost $150 per hour. Heavy lift helicopters that have been used to place large wood cost $8100 per hour. It is often easiest to identify the wood source and volume available and then determine the best design and plan to get the available wood to the project site. Projects that are designed through Watershed Analysis, as part of a forest management plan, or efforts of similar scope, can be very low cost. LWD projects may be best done in support of other land management activities in keeping with long-term land management planning efforts. A documented example cost less than $15K/ river mile to design, monitor, gather, and place LWD approximating old growth forest levels in a large river (Palix River, SW Washington). In similar cases, partnerships with landowners in performing projects as part of land management activities resulted in landowners paying the costs for bridge and road improvements, and donating LWD and other items needed to ensure project success (Spyder Creek, SW Washington and many others).

1.5.6 Monitoring and Tracking

Wood tagging is a technique to monitor the distance of travel for individual pieces of that are expected to move downstream.

Reach bases spawning gravel surveys, large wood habitat surveys, snorkeling surveys before and after wood supplementation are techniques that could be used to monitor the effectiveness of the habitat and determine the degree of fish utilization.

For a comprehensive review of habitat-monitoring protocols, refer to *Inventory and Monitoring of Salmon Habitat in the Pacific Northwest –Directory and Synthesis of Protocols and Management/Research and Volunteers in Washington, Oregon, Idaho, Montana, and British Columbia.*[4]

1.5.7 Contracting Considerations

Construction contracts and time and material contracts are two ways to complete wood supplementation projects. Time and materials construction provides designers the ability to adjust wood to field conditions found on site. Often, unforeseen events create conditions where a field change would make the project better. This is a great advantage to time and materials construction. It assumes a motivated and fair contractor.

To insure exact project costs a construction contract is another way to build a project. This type of contract places more of the project cost liability on the contractor. Construction contracts require much more design work because all of the wood placements have to be specified on paper. The disadvantage to construction contracts is there is limited ability to make a change without an adjustment in compensation. In both forms of construction, oversight by experienced practitioners is recommended to insure designs are being constructed properly.

1.6 Operations and Maintenance

Wood placements used to supplement downstream habitat should be monitored and adjusted if the size or volume of wood is inadequate with the desired and planned objectives. Periodic supplementations may be necessary to maintain habitat until a source of material is reestablished through riparian zone restoration. The frequency or periodic supplementation should rely on monitoring the project reach to determine the effectiveness of the previous treatments.

1.7 Examples

Cascade West Side

Clear Branch Creek wood supplementation used logs and whole trees to supply the stream channel, valley bottom and reclaimed gravel pit within the floodplain with large wood roughness. The volume used approached that of a second growth forested stand and was delivered to the site with a heavy helicopter.

Tucannon River – from WDFW
Touchet River – from WDFW
WDFW - Talk with Yakamas about work in Yakima River Basin

Southwest Washington

Palix River LWD Placement Project, 1998: Canon River, WRIA 24.0435, RM 2 – 7.

The Palix River Watershed Analysis LWD Placement Protocol was implemented in 1998. This is one of the largest LWD placement projects recorded, with over 800 key sized LWD pieces and several thousand functional sized LWD pieces placed in 5 miles of a large river. The project site is in a road less section of two private forest harvest management areas. Monitoring has been a major element of the project and continues from project inception to today. Monitoring includes in stream flows, LWD volumes and movements, gravel bed scour and deposition, and fish population monitoring of most life stages. Because this project developed with a broad social, technical and administrative base compliance monitoring was intensive. Permit, grant, and landowner plan compliance was excellent. The Palix River was catastrophically splash dammed to bedrock during the 1900s. The project focused on re-establishing natural processes that provide habitat functions and recognized the dynamic nature of streams, including disturbance processes. LWD loading met estimated old growth conditions, within the permitted LWD placement area. Permitting requirements reduced the original scope of this project by 50%, and did not allow wood placement in the lower 2 miles of the project area. This is the area where the river begins confluence with William Bay, and was a key part of the original design. Live trees were cut from the forest close to the river. Harvest trees were carefully selected for project LWD to avoid impacting existing forest stands, habitat potentials and riparian zone functions. Project LWD was positioned and distributed to allow the river to shift into a more fish friendly shape. Some key pieces were placed pinned between bank growing trees, or wedged against bedrock formations, no wood was artificially anchored down. Most LWD was simply placed in the river proximate to harvest sites at points of low impact access. All LWD, project placed, and existing LWD, was tagged and tracked. Natural recruitment of LWD was tagged and tracked. Tree boles were yarded to placement using a specially designed high capacity winch vehicle, which moved as a sled over terrain. This vehicle could be positioned, cabled down, and used almost anywhere within the stream corridor with little or no risk of impact but required a high degree of skill to safely operate. Experienced professional loggers crewed the operation and the project's lead scientist as called for provided guidance in wood selection and placement. Most placed LWD did not include root wads, however many very large volume pieces of fir, cedar and hemlock were placed in the channel. Since project construction in 1998 the Palix River has been exposed to several large storm events, and at least one event of 100-year flow reoccurrence magnitude or greater. Habitat quality and quantity in the Palix River has increased since project construction. Monitoring results show increased salmonid population diversity in life stages and number of juveniles rearing in the area. All freshwater life stages of cutthroat and steelhead trout, coho, chinook and chum salmon are now found at times rearing in the project area. Prior to the project fish life stage diversity found in the area at any one time was very low, and some life stages of most species were not observed even though little or no places to hide for these fish existed prior to the project. Chum salmon are a key species to restoration of productivity and properly functioning condition in this river. Chum salmon spawn as large groups intensively using gravel bed reaches of the lower river. Prior to this project many of the chum spawning beds were shallow over bedrock. Some of these beds were controlled by channel spanning "level to bed" alder LWD. The high decay rate of alder as LWD controlling spawner beds and the lack of LWD control of other gravel beds resulted in periodic "broad-cast scour" of entire gravel beds, including any fish redds present. Since the most powerful in stream flows tended to occur at times of the year that chum redds were incubating in these beds, this population was impacted. Chum salmon spawner recruit analysis shows that over the 27 years of record an average of one of three chum generations failed to reproduce brood year return number. Since three years is the average chum generation period, this population was being significantly impacted by conditions, other than harvest, prior to the project. Now cedar and fir has stabilized many of these spawner beds so that broadcast scour appears to be reduced. Project results are at times are not too technical or obscure to entirely trust. Gravel beds in the project area, including the lower river, now are less compacted with fine sediments as a result of LWD in the channel, Juvenile chum salmon commonly use porous gravel substrate as shelter and transient rearing habitat during seaward migration. Prior to the project chum juvenile transitional rearing habitat was so rare that simply simply dipping a single hand down into the water and lifting fish up could easily capture migrating juvenile chum juveniles. Now, in areas affected by the project, they dart instantly into riverbed shelter when threatened with capture. Natural LWD recruitment rates appear to be too low at this time to maintain habitat gains realized from this project. Additional LWD placement work based on the 1998 effort appears warranted for the Palix River.

1.8 References

Johnson, D., J. A. Silver, N. Pittman, E. Wilder, R. W. Plotnikoff, B. C. Mason, K. K. Jones, P. Roger, T. A. O'Neil, and C. Barrett. 2001. Inventory and Monitoring of Salmon Habitat in the Pacific Northwest-Directory and Synthesis of Protocols for Management/Research and Volunteers in Washington, Oregon, Idaho, Montana, and British Columbia. Washington Department of Fish and Wildlife, Olympia, WA.

Montgomery, D.R., J.M. Buffington, R.D. Smith, K.M. Schmidt, and G. Pess. 1995. Pool spacing in forest channels. Water Resources Research 31:4. 1097-1105.

1.9 Photo and Drawing File Names

No drawings will be provided for this technique.

AddLWD Photo1.jpg
AddLWD Photo2.jpg
Need an east side photo with willow etc. and photos showing a smaller scope than the two photos I have.